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NUCLEAR PROPULSION

Title: A FEW COMMENTS ON ROCKETRY

Author: Professor Theodore von Kármán, Chairman, Advisory Group for Aeronautical Research and Development, N.A.T.O., Paris

Source: Interavia, Vol. VIII, No. 11, 1953, p. 628-629

VERBATIM QUOTATION

Dr. von Kármán mentions unconventional methods of propulsion only in the following words:

p. 628

"The rocket ejects matter (or radiation as visualized in the imagination of some planners of future rocketry) which is entirely carried in the vehicle to be propelled."

p. 629

"Finally there is the problem of the nuclear rocket, at least in its clearest form, which uses a nuclear process to supply heat to a fluid with low molecular weight. Even this proposal involves, of course, the still unsolved problem of extracting a controlled amount of heat from the nuclear reactor and transferring it at high temperature to the 'working fluid'. Furthermore, the necessary shielding presents a weight problem. However, for large rockets, the weight of shielding may be balanced by the reduction in the weight of the matter which would have to be ejected by an ordinary rocket."

DAC NOTE:

Dr. von Kármán makes no reference to anti-gravitics, electrical propulsion, etc., although this would have been an obvious opportunity to do so, had he wished to emphasise this subject.

W. B. Klemperer
12-6-54

Title: THE USE OF ATOMIC POWER FOR ROCKETS

Author: Dr. Robert Serber (U. of Calif.)

Source: Research Memorandum #1, Project RAND, July 5, 1946 (UNCLASSIFIED) Also reprinted as Appendix IV to Second Quarterly Report on Project RAND, September 1, 1946, RA-15004

DAC COMMENTS

This report which discussed the outlook of propulsion by nuclear power at a relatively early (1946) stage of the development of nuclear power appliances assessed the possible momentum recovery from any conceivable direct exploitation of the energy of fission products of nuclear reactions as extremely inefficient and unattractive. Fission fragments have high velocity but short range and small momentum. Alpha particles fly in all directions, hence half of their energy would have to be absorbed aboard, so something like 1000 times the kinetic energy of rocket flight would have to be transformed into heat and gotten rid of somehow. This leaves the utilization of the nuclear reaction heat for the ejection of an inert working fluid as the only practical solution. Efflux velocity becomes maximmm when the total supply of working fluid amounts to about four times the empty end mass of the vehicle.

These conclusions are in full agreement with similar deductions published in many scientific articles published since then.

Listings: None

Reference: Serial 006 (LIA 750-121)

12/2/54
W.B. Klemperer

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NUCLEAR PROPULSION

Title: ATOMIC POWERED ROCKETS

Author: Cedric Giles

Source: Journal of the American Rocket Society #63, Sept 1945

DAC ABSTRACT AND COMMENT

This is an early speculative assessment of the possibilities of the application of nuclear power to Rocket Propulsion, attempted immediately after the release of the Smyth Report in August 1945. The author thinks of such things as: Fission released energy to heat liquids or gases to be expelled to drive turbines or to be exhausted directly, electron beams to split water into oxygen and hydrogen which would then recombine chemically as steam; atomic jet impelled reaction power plants (?) "electrostatic or magnetic fields produced as a by-product (?) of atomic energy". The article contains no real technical contribution to knowledge.

Listings: LIA 750-1

WBK
Dec. 15 '54

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NUCLEAR PROPULSION
ELECTROMAGNETIC PROPULSION

Title: A CONTRIBUTION TO THE LEVITATION PROBLEM

Author: Cedric Giles

Source: Journal of the American Rocket Society, No. 70, June 1947, p. 33

Verbatim Quotation:

"A few years ago a suggestion[1] was made that a special type of reflector might be used to control the direction of atomic particles for providing a reaction to the rocket. The general idea may be considered similar to the principle of reflecting light rays in straight lines from a parabolic mirror which has a source of light at its focus point.

"As in Fig. 2, atomic particles would emanate from a fixed source of radioactive energy and on meeting a form of electromagnetic parabolic reflector would be reflected in parallel lines opposite to the direction of travel by the rocket. As discharged particles are now controlled in the cyclotron by magnetic forces the possibility of eventually developing such a source of reflected energy was not considered too remote.

Reference

[1] U.S. Naval Institute Proceedings, June 1942."

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ELECTROMAGNETIC PROPULSION

NUCLEAR PROPULSION

Title: ON THE APPLICATION OF A REACTION FORCE RESULTING FROM AN INTERACTION OF WAVES IN AN ELLIPTIC REFLECTION SPACE

Author: Hans J. Kaeppeler

Source: Rocketscience, vol. 4 #1, March 50, p. 6

Title: ON A THEORY OF POLAR FORCES AS A PRINCIPLE FOR APPLICATION OF ATOMIC ENERGY TO ROCKET PROPULSION

Author: Hans J. Kaeppeler

Source: Rocketscience vol 5 #2 June 51, p. 34 (Pt. I)
vol 5 #3 Sept 51, p. 64 (Pt. II)
vol 5 #4 Dec 51, p. 83 (Pt. III)
vol 6 #1 Mar 52, p. 20 (Pt. IV)
vol 6 #2 June 52, p. 41 (Pt. V)

<u>DAC ABSTRACT AND COMMENTS</u>

Kaeppeler develops a theory of the generation of thrust from a highly hypothetical radiation engine comprising an interior reflector in the shape of a prolate ellipsoid of revolution in the forward focus of which a pulsating source of nuclear energy generates enormously intense radiation and induces an opposite phase pulsation at the rear focus. The reflector shell is open at the rear end. The very involved mathematical calculations are allegedly based on an analogy with the forces generated in a fluid between two sources pulsating in antisymmetric unison source-sink action.

Kaeppeler makes light of the technical problems conjured up in the design of the mirror shell and the containment of the enormous temperatures necessary to yield any sizable thrust effect. He assumes deuterium-helium processes and nonchalantly (!) speaks of temperatures of 2 million degrees, envisages a reflector shell 1 m long, exhaust velocity 1000 km/sec, tons of liquid heavy hydrogen and other fantastic or visionary requisites. The author's imagination is rather uninhibited.

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ELECTROMAGNETIC PROPULSION
NUCLEAR PROPULSION

NOTE 1: The articles were submitted to the Journal of the Detroit Rocket Society, Inc. in German and translated by A. J. Zaehringer, editor of the Journal. The translation is in many places non-idiomatic and therefore even more difficult to understand than (presumably) the original text.

NOTE 2: "About the Author: Although born in 1926 he has already done much in the field of rockets. A member of the BIS, DRS and GfW he has written many articles. He attended the University of Dillingen and Tuebingen where he had studied theoretical physics. His early education was at Dillingen and Weissenhorn. During the war he was a member of the German Air Force. After the last war he worked at the Power Plant Laboratory at Wright Field, Ohio as an assistant of Dr. W. C. Noeggerath and later working with the U.S. Military Government in Germany. He is now Chief Research Specialist for the USAF Historical Research Division, Ulm/Donau, Germany."

(Dr. Noeggerath, now with Lockheed Missiles Group, in a telephone conversation stated that he remembers Kaeppeler only vaguely as a POW detailed to do draftsman's duties at Wright Field until sent home. Kaeppeler left the impression of an eager beaver with a flair for scientific grandiloquence. In 1952 Kaeppeler was a very busy member of the IIIrd Astronautics Congress in Stutgart.)

Listings: LIA 780-2
A-GC 1421 (Second title)

W. B. Klemperer
December 15, 1954

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Title: ATOMIC POWER FOR AIRCRAFT

Author: A. Kalitinsky

Source: SAE Quarterly Transactions, Jan. 1949, Vol. 3 No. 1, p. 15
(also AeroDigest, vol. 57, Aug 1948, p. 58, 59, 121, 123)

VERBATIM QUOTATION

"Types of Atomic Power Plants

"Several basic types of powerplants can be adapted to utilize atomic energy for the propulsion of aircraft. They are all thermal powerplants, since fission energy is released predominantly in the form of heat. Some thought has been given to the direct production of electricity from the fission process, but there is at present, no known practical way of achieving this."

...

"Fig. 13 shows the application of nuclear energy to a rocket. A propellant, for instance liquid hydrogen, is pumped out of the tank and through the reactor, where it is vaporized and heated to a high temperature. It then escapes at high velocity through the exhaust nozzle. The rocket is driven by the recoil of the escaping propellant, and is therefore not dependent on atmospheric air for its functioning. It can, therefore, operate outside the earth's atmosphere. One may well ask where the advantage lies in using nuclear energy for a rocket, since its endurance is limited, as it can operate only until the propellant is exhausted, regardless of the practically unlimited supply of energy in the reactor. The reason why nuclear energy offers a definite advantage in rockets is that the specific impulse of a rocket propellant, the pounds of thrust that can be obtained from each pound of propellant used per second, is proportional to the square root of the absolute propellant temperature divided by the molecular weight of the propellant. In other words, the highest possible temperature and the lowest possible molecular weight are desired. The high temperature is obtained normally, in a chemical rocket, by the combustion of a fuel and an oxidizer, whose products of combustion are then used as the propellant. Since the weight will obviously be fairly high. For instance, if hydrogen and oxygen are used, the resulting propellant is water vapor, with a molecular weight of 18. On the other hand, if nuclear energy is used to provide the high temperature, there is no need for the process of combustion, and very light propellants, like hydrogen, for instance, with a molecular weight of 2 can be used. Since the ratio of 18 and 2 is 9, and the square root of 9 is 3, the specific impulse of pure hydrogen at the same temperature is three times that of water vapor."

Listings: LIA 750-6

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Astronautics Literature Review

Serial 015

PHOTONIC PROPULSION

Title: INTERSTELLAR FLIGHT

Author: Leslie R. Shepherd, Ph. D.

Source: Journal of the British Interplanetary Society, Vol. 11, No. 4
pp. 149-167 (July 1952)

AUTHOR'S SUMMARY

"The most significant factor in flight to the stars is the vast scale of distances involved. It would be possible, at least in principle, to construct a vehicle, deriving its power from known nuclear reactions, which would be capable of reaching the nearest stars in a period of time measured in centuries. Such a vehicle might achieve a maximum velocity of 5,000 to 10,000 km/sec. One difficult problem would be the attainment of reasonable accelerations in conjunction with the necessary high exhaust velocities. An acceleration of 0.3 cm/sec^2 would be adequate but would involve an almost prohibitive rate of power dissipation.

"Vehicles designed to achieve velocities close to that of light would need to utilize sources of energy far more potent than any known today. Nothing less than the complete conversion of matter into utilizable energy would be sufficient for this purpose. The dynamics of vehicles moving at such high velocities would have to be based upon the principles of special relativity. An important consequence of this would be the reduction of voyage transit times in the traveller's system of reference. Even if one assumes the existence of power sources capable of giving vehicles velocities near to the speed of light, the attainment of useful accelerations would be a formidable problem. Accelerations of the order of 1 g would be necessary, to exploit fully the capabilities of the time-dilatation effect. A hypothetical vehicle propelled by photons would require to develop a useful power rating of 3 billion watts per tonne of vehicle mass (3×10^{12} watts/tonne) to obtain 1 g acceleration. If the photons were radiated from "black body" surfaces, the temperatures involved would be of the order of 100,000°C.

"Interstellar matter would not provide a hazard at vehicle velocities less than 100,000 km/sec., but at near optic velocities, individual nuclei of the interstellar gas would penetrate through considerable thicknesses (10 cm) of solid metal and precautions would have to be taken to protect any people in the vehicle."

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DAC COMMENTS

This is a well-written paper, covering a wide variety of subjects. The published abstract is quite inclusive. However, a few additional comments on the portion of the paper covering photonic rocket propulsion are in order.

The author indicates that for a hypothetical vehicle having a mass ratio of 7.4 and unity efficiency of energy conversion, the true velocity of the vehicle (relative to the system in which it was initially at rest) would be 59/61 times the speed of light (0.967c). Electrically accelerated photons are not considered and the only emission discussed is black body radiation. As mentioned in the abstract, the emitting surface (1 square meter) should have the tremendous temperature of $100,000^{o}$K., and a power of 3×10^{12} watts/tonne of ship mass would be required.

The paper contains an excellent, elementary discussion of relativity as of importance to space travel.

REFERENCES

1. L. R. Shepherd and A. V. Cleaver, JBIS, 7, pp 191-192 (Sept. 1948)
2. L. R. Shepherd and A. V. Cleaver, JBIS, 8, pp 59-70 (March 1949)
3. L. Spitzer, JBIS, 10, pp. 249-257 (Nov. 1951)
4. H. Preston-Thomas, JBIS, 11 (4), pp 173-193 (July 1952)
5. M. W. Ovenden, JBIS, 10, pp 176-180 (July 1951)
6. J. Ackeret, Helvetica Physica Acta (April 1946): JBIS, 6, pp 116-123 (March 1947)

Listings: LIA 664
A-GC 17

12-2-54
G. J. Mueller

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IONIC PROPULSION

Subject: HEAT

Source: Scientific American, Vol. 191, No. 3, September 1954

DAC ABSTRACT:

This extremely instructive and authoritative symposium on the nature and phenomena of heat is composed of the following chapters.

1. Man the Fire-Maker by Loren C. Eiseley
2. What is Heat? by Freeman J. Dyson
3. Heat and Life by Frank H. Johnson
4. High Temperatures: Flame by Bernard Lewis
5. High Temperatures: Materials by Pol Duwez
6. High Temperatures: Chemistry by Farrington Daniels
7. High Temperatures: Propulsion by Martin Summerfield
8. Very High Temperatures by Arthur Kantrowitz
9. Ultrahigh Temperatures by Fred Hoyle

Chapters 7 and 8 contain brief remarks pertaining to methods of propulsion which are unconventional in terms of presently accomplished practice but must be considered as conceivable and compatible with scientific knowledge. These remarks are quoted verbatim below:

From Chapter 7, p. 31.

...
"More advanced jet-propulsion performance will undoubtedly come about through the use of nuclear energy in place of chemical energy, but this development has only just begun. In the near future advances in jet propulsion will come about through the development of more efficient combustion systems and the improvement of the means of converting heat into kinetic energy."

From Chapter 8, p. 140-142

..
"The investigation of the dynamics of very hot gases not only is beginning to unravel many mysteries of our astronomical cosmos but also offers some exciting possibilities in the technology of flight. Our present airplanes -- rocket or jet-propelled -- are ultimately limited in speed by the gas velocity that can be attained by chemical reactions. For practical space flight we shall need much higher velocities. One possible way to attain it is to accelerate gas with magnetic forces instead of merely with chemical combustion. There is no known theoretical limit to the propulsive impulse obtainable from a given mass of gas expelled in this way. The electrical energy for acceleration could be supplied by a nuclear reactor. This propulsion device would be essentially an electric motor with a gas replacing the usual solid armature.

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Scientific American
Sept. 1954

Serial 016

"It may even be possible to find ways to use magneto-hydrodynamic forces for control and lift, as well as for propulsion, of the ships in which man eventually will take off into space."

W. B. Klemperer
Dec. 14, 1954